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EFFECTIVENESS OF USING FABA BEAN SEEDS AND CORN DISTILLERS GRAINS WITH SOLUBLES AS A PARTIAL REPLACEMENT OF SOYBEAN MEAL IN THE FEEDING OF PULAWSKA PIGS

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Abstract. The aim of the present work was to determine fattening and slaughter performance as well as physical properties of meat in Pulawska pigs fed mixtures containing faba beans and corn distillers dried grains with solubles (DDGS). Thirty animals were divided into three equal groups: control (I) and two experimental (II and III). Pigs were kept in pens and fed the same mixtures collectively *ad libitum* throughout the fattening. The only high-protein component of the mixture of the control group was soybean meal, while in mixtures fed to experimental groups, 1/3 of extracted soybean meal protein was replaced by faba bean (group II) or DDGS (group III). Introduction of 10% low-tannin faba bean in the mixtures for pigs did not affect the daily weight gains, while the use of the same amount of corn distillers dried grains with solubles in the diet significantly ($P \leq 0.05$) reduced daily gains and, consequently, the final body weight of the finishers. No effects of the nutrition on lean and fat content in the carcass were noticed. *Longissimus* muscle of pigs fed DDGS was characterized by the highest drip loss after 48 and 72 hours from slaughter ($P \leq 0.05$) and the lowest yellow b* saturation ($P \leq 0.05$).

Key words: corn DDGS, faba bean, fatteners, meat physical properties, productive and slaughter results

INTRODUCTION

Improvement of the efficiency of pigs and poultry production cause a systematic increase in the demand for high-protein raw materials. The most commonly

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used is the post-extraction soybean meal protein feed, which is an imported and expensive feed component. It covers approx. 70% of the requirement for protein in feed mixtures produced in Poland. Protein raw materials of domestic origin, which may partially replace the soybean meal, are the Fabaceae seeds: faba beans, peas and lupines or by-products obtained in the production of ethanol, i.e. distillers dried grains with solubles (DDGS). Breeding work on faba bean given rise to a low-tannin variety, allowing greater use in mixtures for animals [Jamroz and Kubizna 2008, Jezierny et al. 2010, Hanczakowska and Księżak 2012]. In recent times, we have also witnessed an increased interest in distillers dried grains that could be a source of protein in the diet for farm animals. Production of distiller's grains is high and likely to increase, due to the use of ethanol as a biofuel (requirements of international agreements). The drawback of fresh wet distillers grains as livestock animals fodder is the short shelf life, so they must be preserved. As a result, we obtain an extension of their durability, among other distillers dried grains with solubles (DDGS). Good quality dried distillers grain, can be a valuable feed for monogastric animals [Stein and Shurson 2009, Sokół et al. 2010, Xu et al. 2010, Świątkiewicz and Hanczakowska 2011].

The use of alternative feeds in the diet of animals is associated with their impact on the performance and carcass quality, as well as the quality of the final product [Osek and Milczarek 2005, Widmer et al. 2008, Sokół et al. 2010]. Beside the main factor influencing nutrition, effects are dependent on the animal factors (genetic) and the correlation between them [Kmieć et al. 2010, Milczarek et al. 2012, Gatta et al. 2013].

The aim of the study was to determine the results of fattening, slaughter of Pulawska pigs fed mixtures containing low-tannin faba beans or corn distillers dried grains with solubles (DDGS).

MATERIAL AND METHODS

The experiment was conducted in a private farm on 30 Pulawska fatteners. The animals were assigned to three equal groups (I, II, and III) and fattened from the average body weight of about 31 kg to 115 kg. During the experiment (112 days), the animals were kept on deep litter in collective pens (10 heads), equipped with auto-feeders and nipple drinkers. Using *ad libitum* feeding system, the same mixtures were fed throughout the whole fattening cycle. Pigs of the control group (I) were fed a mixture prepared on barley, triticale, soybean meal and vitamin-mineral additives, whereas experimental fatteners were offered mixtures in which part of the soybean meal was replaced by 10% low-tannin faba bean meal (group II) or 10% corn distillers dried grains with solubles (group III; Table 1).

Table 1. Composition and nutritive value of feed mixtures

Tabela 1. Skład i wartość pokarmowa mieszanek

Specification Wyszczególnienie	Grupy – Groups		
	I	II	III
Raw materials, % – Surowce, %			
Barley – Jęczmień	41.50	39.00	39.00
Triticale – Pszenżyto	42.00	38.50	38.50
Soybean meal – Śruta poekstrakcyjna sojowa	14.00	10.00	10.00
Low-tannin faba bean – Bobik niskotaninowy		10.00	
Corn DDGS – Kukurydziany DDGS			10.00
Premix* – Premiks*	2.50	2.50	2.50
Total – Razem	100.00	100.00	100.00
1 kg of mixtures contains – 1 kg mieszanki zawiera			
Metabolizable energy **, MJ Energia metaboliczna **, MJ	12.74	12.69	12.66
Crude protein – Białko ogólne, %	16.26	16.15	16.17
Crude fibre – Włókno surowe, %	3.79	4.06	4.13
Lys, g	8.68	9.15	8.19
Met + Cys, g	5.44	5.22	5.78
Thr, g	5.80	5.89	5.90
Tryp, g	1.79	1.74	1.87
Ca, g	6.32	6.28	6.25
P, g	4.20	4.29	4.60
P available, g	2.65	2.68	2.48
Na, g	1.46	1.45	1.44

* Premix contained: metabolizable energy – min. 1.25 MJ · kg^{-1}, crude protein – min. 90 g · kg^{-1}, lys – min. 65 g · kg^{-1}, met + cys – min. 7 g · kg^{-1}, thr – min. 12.5 g · kg^{-1},Ca – min. 220 g · kg^{-1}, P available – min. 43 g · kg^{-1}, Na – min. 53 g · kg^{-1}.

* Premiks zawierał: energia metaboliczna – min. 1,25 MJ · kg^{-1}, białko ogólne – min. 90 g · kg^{-1}, lys – min. 65 g · kg^{-1}, met + cys – min. 7 g · kg^{-1}, thr – min. 12,5 g · kg^{-1}, Ca – min. 220 g · kg^{-1}, P przyswajalny – min. 43 g · kg^{-1}, Na – min. 53 g · kg^{-1}.

** Metabolizable energy calculated using the equation of Hoffmann and Schiemann [1980].

** Energię metaboliczną wyliczono wg równania Hoffmanna i Schiemanna [1980].

Nutritional value of the mixtures were formulated according to the recommendations of the Polish Standards of Pig Nutrition [1993], based on the results of their own analyzes (Table 2) and tabular data Polish Standards of Pig Nutrition [1993]. Basal nutrients content was determined according to AOAC [1990], and fiber fractions according to the method by Van Soest and Wine [1967]. Mineral content was estimated after prior digestion of the sample and addition of 10 cm^3 of 10% HCl to a 50 cm^3 flask. In the final solutions, the total content of elements was determined by inductively coupled plasma – atomic emission spectrometry (ICP-

AES) using a Perkin Elmer Optima 3200RL spectrometer. Determination of tannins was done by the colorimetric method in accordance with the BN-90/79160-62 and performed at the National Laboratory of Feed in Lublin.

Table 2. Chemical composition of high-protein feeds

Tabela 2. Skład chemiczny surowców wysokobiałkowych

Specification Wyszczególnienie	Soybean meal Śruta poekstrakcyjna sojowa	Low-tannin faba bean Bobik niskotaninowy	Corn distillers grains with soubles (corn DDGS) Suszony wywar kukurydziany (kukurydziany DDGS)
Basal nutrients content , % – Zawartość składników podstawowych, %			
Dry matter – Sucha masa	90.66	88.78	90.98
Crude ash – Popiół surowy	6.61	3.45	4.32
Crude protein – Białko ogólne	46.01	24.13	24.34
Crude fat – Tłuszcz surowy	1.53	0.92	10.85
Crude fibre – Włókno surowe	5.41	7.90	7.94
ADF	5.82	11.94	11.37
NDF	16.23	19.80	28.87
ADL	1.13	2.43	2.32
CEL = ADF – ADL	4.69	9.51	9.05
HCEL= NDF – ADF	10.41	7.86	17.50
N-free extractives – BAW	31.10	52.38	43.53
Mineral composition, g · kg^{-1} – Zawartość składników mineralnych, g · kg^{-1}			
Ca	3.896	1.349	0.923
P	6.279	5.572	8.309
K	22.088	12.902	11.819
Na	0.316	0.110	2.998
Mg	2.679	1.296	2.713
S	0.014	0.611	0.420
Fe	1.239	0.746	1.436
Al	0.267	0.046	0.296
Mn	0.387	0.124	0.117
Co	0.003	0.004	0.001
Mo	0.046	0.004	0.006
B	0.294	0.075	0.039
Ti	0.011	0.003	0.021
Ba	0.104	0.009	0.008
Sr	0.160	0.015	0.014
Cd	0.003	0.004	0.004
Cr	0.004	0.004	0.013
Cu	0.139	0.112	0.085
Zn	0.608	0.580	0.752
Ni	0.031	0.019	0.009
Tannins – Taniny, g · kg^{-1}	ND	4.01	ND

ND – not determined.
ND – nie oznaczano.

The animals were weighed on both the commencement and the completion of the experiment, and the daily weight gains were calculated. During the fattening we also monitored the feed intake in order to calculate the feed conversion ratio (FCR) per kilogram of body weight. The animals were slaughtered on the last day of fattening according to the current technology, and carcass lean meat and fat content was evaluated using the UltraFom 300 ultrasound probe. In 45 minutes post-slaughter, the initial pH of meat (pH_1) was measured in the *longissimus dorsi* muscle, between the last breast and the first lumbar vertebra. The measurement was made using a portable pH meter (Mettler Tolledo) equipped with a glass electrode (daggers). The carcasses were chilled for 24 hours in temperature 0–4°C, and the acidity of meat (pH_{24}) was measured again. The length of carcass was measured on the right halves and back fat thickness was measured in five places. Next, dissection was performed according to the methodology used in SKURTCh [Różycki 1996], then samples of meat from the loin (*musculus longissimus lumborum*) and ham (*musculus adductor femoris*) were taken for physical analysis. The muscles drip loss after 48 and 72 hours post slaughter were determined according to the methodology by Prange et al. [1977], and water holding capacity was established according to Grau and Hamm [1953] method with Pohja and Ninivarra [1957] modifications. The instrumental colour evaluation was made using a tristimulus colorimeter Minolta CR–310.

The system of L* a* b* is the model of colour. In the applied measuring system, L* represents lightness, a* parameter corresponds to red or green colour, and b* parameter – yellow or blue colour. Based on the obtained results of colour parameters, chroma index was calculated, following the equation: $C^* = [(a^*)^2 + +(b^*)^2]^{0.5}$ (Strzyżewski et al. 2008).

The results were statistically analyzed using one-way analysis of variance (ANOVA), the significance of differences between mean values were tested with Duncan's test.

RESULTS AND DISCUSSION

The chemical composition of high-protein feeds, i.e.: soybean meal, low-tannin faba bean and corn distillers dried grains with solubles (DDGS) used in mixtures for pigs are presented in Table 1.

Low-tannin faba bean used in the mixture for pigs contained by approx. 5 percentage points less protein as compared to the amount determined by Szpunar-Krok et al. [2009], but its content was in the range of 21.8–27.5% declared by Zijlstra et al. [2008] and Kiarie et al. [2013]. The level of crude fiber and the fractions was similar to the amount reported by Zijlstra et al. [2008] and Kiarie et al. [2013], but the authors have shown differences in the percentage of the individual

fractions. The level of ADF and NDF fractions measured th our experiment was higher than that shown in the studies of Beltrena et al. [2009] and Kiarie et al. [2013], but it remained within the ranges given by Zijlstra et al. [2008] as well as Woyengo and Nyachoti [2012]. The mineral content (Ca, P and Na) was slightly higher than reported by Matyka [2007] in the seeds of faba bean and Polish Standards of Pig Nutrition [2014]. Less Ca, Mg, K, Fe, Zn in low-tannin faba bean were reported by Szpunar et al. [2009]. The tannin content 4.01 $g \cdot kg^{-1}$ in low-tannin faba bean ranged from undetectable to 1% of the administered by Jansman [1993], Duc et al. [1999], Jezierny et al. [2009], Woyengo and Nyachoti [2012] and Kiarie et al. [2013].

The humidity of corn distillers dried grains with solubles was below 10%, and a sensory analysis raised no reservation as to its quality. The protein content of the corn DDGS was similar to the quantity reported by Szulc et al. [2011] and lower than that indicated by Świątkiewicz et al. [2013] and the Polish Standards of Pig Nutrition [2014]. In terms of chemical composition in reference to the Standards of Nutrition of Pigs [2014], the applied corn distillers dried grains contained less crude fat (1.04%) and ash (about 0.88%) with a comparable amount (7.94% vs. 7.9%) of crude fiber. The share of individual fiber fraction was similar to results obtained by Świątkiewicz et al. [2013]. The corn distillers dried grains with solubles used in our experiment contained less Ca (about 0.18g) and more P (about 2.9 g) and Na (about 2.5 g) in relation to the content of these elements recommended in the Polish Standards of Pig Nutrition [2014]. The studies by Curry et al. [2014] showed less (0.07%) Ca and more (0.90%) P in DDGS.

Introducing two different replacements of soybean meal to mixtures had an impact on the final body weight of pigs (Table 3). The pigs fed mixtures with corn distillers dried grains with solubles (group III) had significantly ($P \leq 0.05$) lower body weight in comparison to both group of the pigs: control (group I) and fed with the mixture containing faba bean (group II). Daily gains of the pigs were lower, respectively 95 g and 69 g.

A reduction in daily gains of pigs fed diet containing wheat distiller dried grains with solubles (9 or 21%), with an increased feed conversion ratio, was reported by Sokół et al. [2010]. Świątkiewicz et al. [2013], who applied a higher proportion (15%) of corn DDGS to feeds for pigs did not notice a reduction in body weight gains or increased feed conversion. Zijlstra et al. [2008] showed that the introduction 30% of low-tannin faba bean into mixtures for fatteners as a substitute of soybean meal allows obtaining similar body weight gains.

The carcass slaughter value is determined by its lean meat and fat content. The use of the experimental feeds mixtures for pigs did not influence significantly the dressing percentage, meatiness, loin eye area, or the average thickness of back fat, which confirms the results of Sokół et al. [2010] as well as Świątkiewicz et al.

Table 3. Fattening and post-slaughter performance of pigs

Tabela 3. Wyniki tuczu i poubojowe świń

Trait Cecha	Grupy – Groups			SEM
	I	II	III	
Body weight, kg – Masa ciała, kg				
initial – początkowa	30.5	30.5	31.5	1.13
finished – końcowa	119.5 a	116.5 a	110.0 b	1.95
Daily gains, g – Przyrosty dobowe, g	795 a	769 a	700 b	8.38
Average daily feed intake per fattener, kg Średnie spożycie paszy przez tucznika, kg	2.72	2.65	2.35	–
Feed conversion ratio (FCR), kg feed · kg BWG^{-1} Zużycie paszy (FCR), kg paszy · kg przyrostu^{-1}	3.42	3.45	3.35	–
Dressing percentage, % – Wydajność rzeźna, %	76.86	77.11	76.33	0.65
Meatiness, % – Mięsność, %	49.60	51.90	49.58	1.15
Carcass lenght, cm – Długość tuszy, cm	88.5	87.0	87.0	1.06
backfat thickness mean from 5 measurment, mm średnia grubość słoniny z 5 pomiarów, mm	30.20	30.05	31.70	1.32
Lard weight, kg – Masa sadła, kg	2.35 a	1.51 b	1.81 b	0.24
Loin eye area, cm^2 Powierzchnia oka polędwicy, cm^2	50.91	51.78	49.08	1.68
Weight of primal cuts of right half-carcass, kg Masa najważniejszych wyrębów podstawowych prawej półtuszy, kg				
neck – karkówka	6.70	6.33	6.10	0.19
shoulder – łopatka	6.45	6.21	6.13	0.18
steak and ribs – boczek z żeberkami	6.93 a	6.44 ab	5.96 b	0.12
ham with skin – szynka ze skórą	12.56	11.93	12.12	0.21
ham – szynka	11.75	11.15	11.33	0.20
fillet – polędwica	8.80 a	8.64 a	7.76 b	0.13
m. longissimus	3.12 a	3.07 ab	2.76 b	0.11

a, b – Means in rows with different letters differed significantly at $P \leq 0.05$.
a, b – Wartości w wierszach oznaczone rożnymi literami rożnią się istotnie przy $P \leq 0,05$.

[2013]. It is difficult to compare these data with our results, since the authors noted a much better fleshiness and thinner back fat in hybrid of typical meat breeds.

Assessing the quality of the meat based on the concentration of hydrogen ions in the *longissimus* muscle demonstrated that it was characteristic of normal meat (pH measured at 45 min and 24 hrs. after slaughter was >5.8 and <6.0 [Pospiech 2000]. The greatest (3.43%) drip loss measured 48 hours after slaughter was found in *m. longissimus* of pigs fed mixtures with DDGS, and the difference as compared to control animals and group II was significant ($P \leq 0.05$). Similar results were seen after another 24 hours, and the difference was confirmed as statistically significant between the group II and III, on positive of group II. No effect on the pH of the experimental feeds and water holding capacity (WHC) muscle is consi-

stent with studies by Sokół et al. [2010], Xu et al. [2010], Gatta et al. [2013] and Świątkiewicz et al. [2013]. An increase in drip loss from the *longissimus* muscle, from 3.14% to 3.73%, after addition of 10% corn DDGS to the feed was also noted by Xu et al. [2010].

Table 4. Physical characteristic of muscles

Tabela 4. Cechy fizyczne mięśni

Trait Cecha	Grupy – Groups			SEM
	I	II	III	
Musclus longissimus				
pH_1	6.06	6.02	5.89	0.08
pH_{24}	5.56	5.69	5.48	0.06
Water holding capacity (WHC), % Wodochłonność (WHC), %	25.34	25.04	26.99	0.69
Drip loss after 48 hours, % Wyciek naturalny po 48 godz., %	2.13 b	2.04 b	3.43 a	0.27
Drip loss after 72 hours, % Wyciek naturalny po 72 godz., %	5.17 ab	4.89 b	6.43 a	0.30
Colour – Barwa				
L*	52.91	51.91	52.60	1.12
a*	10.50	10.80	9.34	0.86
b*	2.78 a	2.57 a	1.67 b	0.36
$C^* = [(a^*)^2 + (b^*)^2]^{0.5}$	10.86	11.11	9.49	0.94
Musclus adductor				
Water holding capacity (WHC), %	21.01	22.59	22.01	0.64
Colour – Barwa				
L*	47.41	49.45	49.88	1.61
a*	10.73	11.45	9.69	0.73
b*	1.80	2.96	1.71	0.62
$C^* = [(a^*)^2 + (b^*)^2]^{0.5}$	10.88	11.82	9.84	0.71

a, b – Means in rows with different letters differed significantly at $P \leq 0.05$.
a, b – Wartości w wierszach oznaczone rożnymi literami rożnią się istotnie przy $P \leq 0{,}05$.

Meat colour is crucial to its quality, since it determines the appearance and attractiveness in the eyes of the consumer. Significantly the lowest ($P \leq 0.05$) colour saturation of yellow had *longissimus* muscle of pigs fed a mixture of corn distillers dried grains with solubles. Similarly Widmer et al. [2008] and Świątkiewicz et al. [2013] noted a decrease in saturation of yellow b* in the muscle after adding DDGS. No effect of the application of faba bean in the mixtures for pigs on the parameters of the L* a* b* colour in the *longissimus* muscle is a confirmation of results by Gatta et al. [2013].

CONCLUSIONS

The study showed that it can be recommend to replace 1/3 of protein of extracted soybean meal in the mixture for Pulawska breed pigs by low-tannin faba bean, as this results in fattening performance, slaughter carcass value and physical properties of meat comparable with the control group. Application of the same amount of protein in the form of corn distillers dried grains with solubles (DDGS) in place of the extracted soybean meal components decreased fattening outcomes, had no effect on fatness and fleshiness of carcasses, though it elevated drip loss and yellow colour saturation of *longissimus* muscle.

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EFEKTYWNOŚĆ STOSOWANIA NASION BOBIKU I SUSZONEGO WYWARU KUKURYDZIANEGO JAKO CZĘŚCIOWYCH ZAMIENNIKÓW POEKSTRAKCYJNEJ ŚRUTY SOJOWEJ W ŻYWIENIU ŚWIŃ RASY PUŁAWSKIEJ

Streszczenie. Celem badań było określenie wyników tuczu i wartości rzeźnej świń oraz cech fizycznych mięsa rasy puławskiej żywionych mieszankami zawierającymi bobik niskotaninowy lub suszony wywar kukurydziany (DDGS). Trzydzieści zwierząt podzielono na 3 równoliczne grupy: kontrolną (I) i dwie doświadczalne (II i III). Świnie utrzymywano w kojcach zbiorowych i żywiono *ad libitum*, tymi samymi mieszankami przez cały tucz. W mieszance dla zwierząt grupy kontrolnej jedynym surowcem wysokobiałkowym była śruta poekstrakcyjna sojowa, natomiast w mieszankach dla grup doświadczalnych 1/3 białka śruty poekstrakcyjnej sojowej zastąpiono bobikiem (grupa II) lub DDGS (grupa III). Wprowadzenie 10% bobiku niskotaninowego do mieszanki dla tuczników nie wpłynęło na dobowe przyrosty masy ciała, natomiast zastosowanie takiej samej ilości suszonego wywaru kukurydzianego w mieszance istotnie ($P \leq 0,05$) obniżyło przyrosty, a w konsekwencji końcową masę ciała świń. Nie zanotowano wpływu pasz doświadczanych na umięśnienie i otłuszczenie tusz. Mięsień *longissimus* świń żywionych mieszanką z DDGS charakteryzował się największym wyciekiem naturalnym po 48 i 72 godzinach od uboju ($P \leq 0,05$) oraz najmniejszym wysyceniem barwy żółtej b* ($P \leq 0,05$).

Słowa kluczowe: bobik, cechy fizyczne mięsa, DDGS kukurydziany, tuczniki, wyniki produkcyjne i poubojowe

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